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Summary of Water Quality in Gregoire Lake 1989-1993

by:

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Summary of Water Quality in Gregoire Lake

Alberta Environmental Protection has conducted a water quality monitoring program on Gregoire Lake since 1989. It is one of about 30 lakes monitored regularly by staff of Parks Services and Water Resources Services. The purpose of the ongoing sampling program is to obtain long-term information on the fertility level of this and other recreational lakes associated with provincial parks so that trends may be detected.

General physical characteristics of Gregoire Lake are presented in Table 1, and shoreline features in Figure 1. Additional information is available in the *Atlas of Alberta Lakes*. The lake is fairly shallow for its size, and its watershed is large compared to the size of the lake. Lake levels have been an ongoing concern on this lake, although there has been no decline in lake level as in many other lakes in the northeastern part of the province (Figure 2).

Table 1. Characteristics of Gregoire Lake.

Elevation (m) on date of sounding, Oct. 1982	475.17
Surface Area (km^2)	25.8
Volume (m^3)	100×10^6
Maximum Depth (m)	7.2
Mean Depth (m)	3.9
Shoreline Length (km)	32.2
Mean Residence Time (yr)	4
Watershed Area (km^2) excluding lake	232

Source: Data are from Alberta Environmental Protection as published in *Atlas of Alberta Lakes,* P. Mitchell and E. Prepas, eds., 1990, University of Alberta Press, Edmonton.

The Sampling Program

The emphasis of the sampling program is on indicators of recreational water quality, including the phosphorus content of the lake water (which usually governs the amount of plant material in the lake), the amount of algae, the water's transparency (as measured by the depth a Secchi disk is visible) and counts of coliform bacteria along beaches.

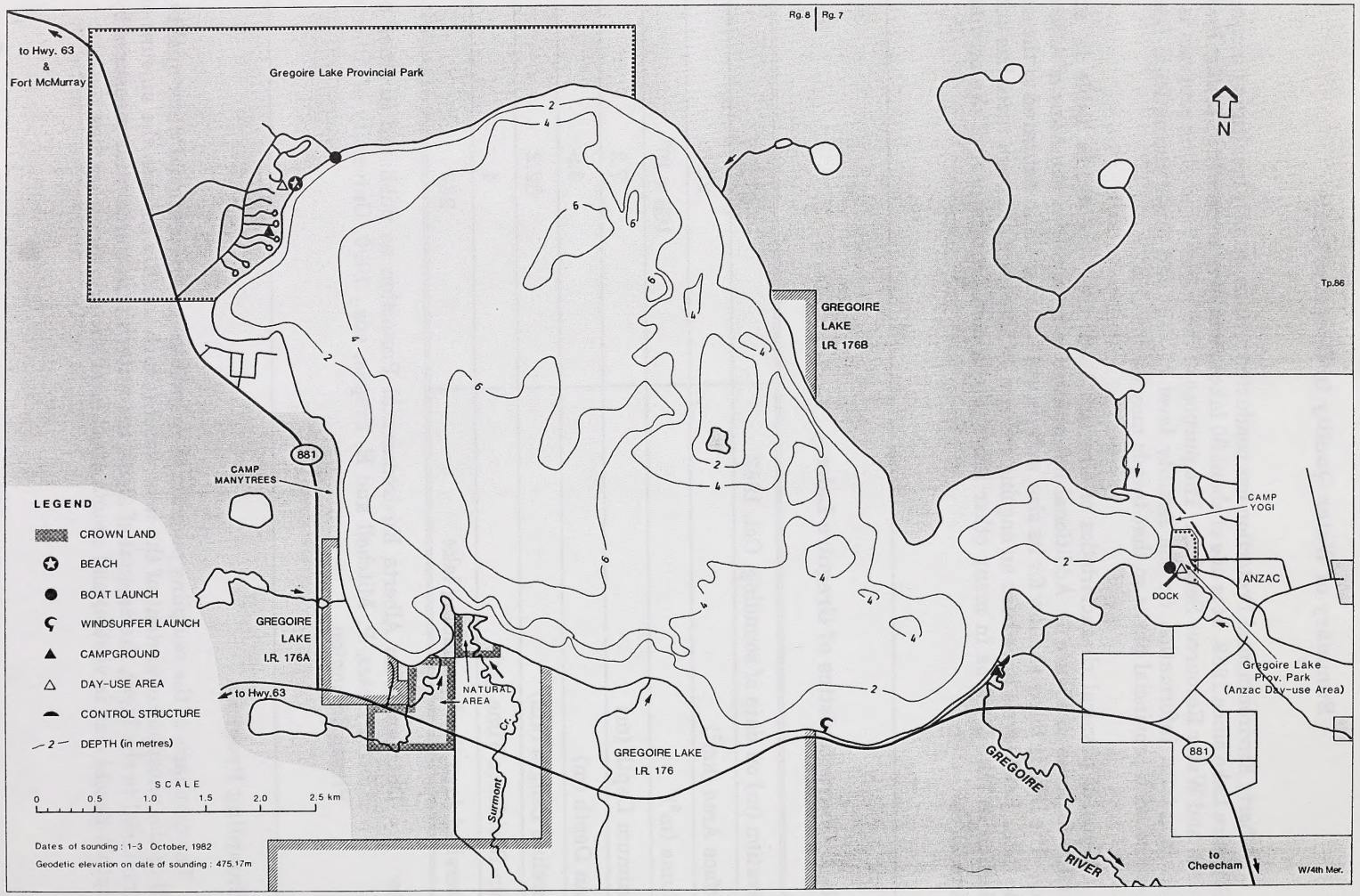
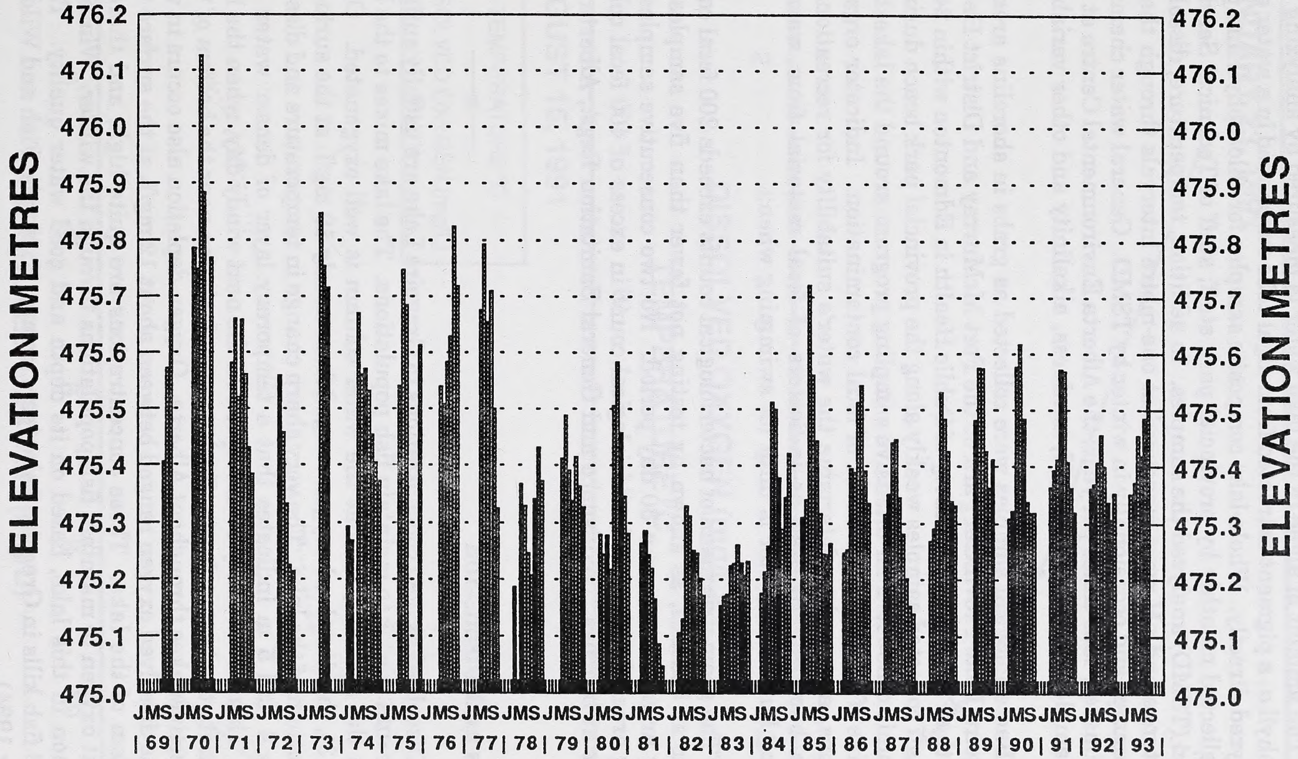


Figure 1. Bathymetric map of Gregoire Lake

FIGURE 2. GREGOIRE LAKE (07CE001)
MONTHLY MEAN LAKE LEVELS



MAXIMUM DAILY W.L. ON RECORD: 476.29M JUL 05/70
MINIMUM DAILY W.L. ON RECORD: 475.01M OCT 07/81
LATEST AVAILABLE DAILY W.L.: 475.45M SEP 29/93

The amount of algae in the lake water is measured by analyzing the concentration of chlorophyll *a*, a pigment extracted from algal cells suspended in a water sample. Phosphorus is analyzed directly. Whole-lake composite samples for chlorophyll and phosphorus analysis were collected monthly by provincial park staff; staff of Technical Services and Monitoring Division (TSMD) analyzed the samples. In addition, temperature, dissolved oxygen, specific conductance and pH were measured at one-metre intervals through the water column once each summer and occasionally in winter by TSMD. General water chemistry was monitored approximately four times per year; the Alberta Environmental Centre at Vegreville analyzed these samples for major ions, pH, hardness, alkalinity and other variables.

Bacteriological samples were collected as grabs in shoreline areas or creeks by staff of Gregoire Lake Provincial Park or the Fort McMurray and District Health Unit, and were sent to the Provincial Laboratory of Public Health in Edmonton within 24 hours of collection. Park staff collected samples weekly along the provincial park beach during summer, and the health unit conducted an intensive sampling program around the lakeshore in July 1993 to determine if there were sources of fecal contamination. Indicator organisms, rather than pathogens, are used to determine the water's suitability for recreational activities. Fecal coliform bacteria are used as indicators of fecal material from warm-blooded animals, including humans. Water is unfit for swimming when:

"The geometric mean of bacteriological counts exceeds 200 fecal coliforms per 100 mL of water at beaches, as shown by testing not fewer than five samples of water from the bathing area taken over a 30 day period. No two consecutive samples of water from the bathing area shall have a bacteriological count in excess of 400 fecal coliforms per 100 mL of water at beaches." (Nuisance and General Sanitation Regs., Alberta Public Health Act, 1985).

Results and Discussion

Dissolved oxygen concentrations in Gregoire Lake are usually sufficiently high during summer and winter to maintain fish populations. The lake mixes to the bottom periodically through the summer, so that the water column is well oxygenated. On August 15, 1991 (Figure 3), the dissolved oxygen ranged from nearly 10 mg/L at the surface to nearly 0 mg/L at the bottom of the lake. The very sharp change in temperature and dissolved oxygen levels between 4 and 5 m indicates that a temporary layer of denser water had formed at the bottom. This would likely be disrupted on the next windy day, when the lake would mix and reoxygenate the bottom layer. Such oxygen depletion near the bottom of the lake is common in productive lakes throughout Alberta. Oxygen depletion also occurs in winter. In January 1991, the dissolved oxygen ranged between about 12 mg/L at the surface to nearly 7 mg/L at the bottom of the lake. These concentrations are quite high, and there would have been sufficient oxygen to maintain fish populations through the winter. Winterkill would be very uncommon in this lake, based on its depth and good water quality. There have been no recorded fish kills in Gregoire Lake (pers. comm. H. Norris, Fish and Wildlife Services, AEP, January 1994).

The results of the beach sampling for fecal coliforms in 1993 indicated relatively high counts (greater than 240 organisms per 100 mL sample) along the provincial park beach. In

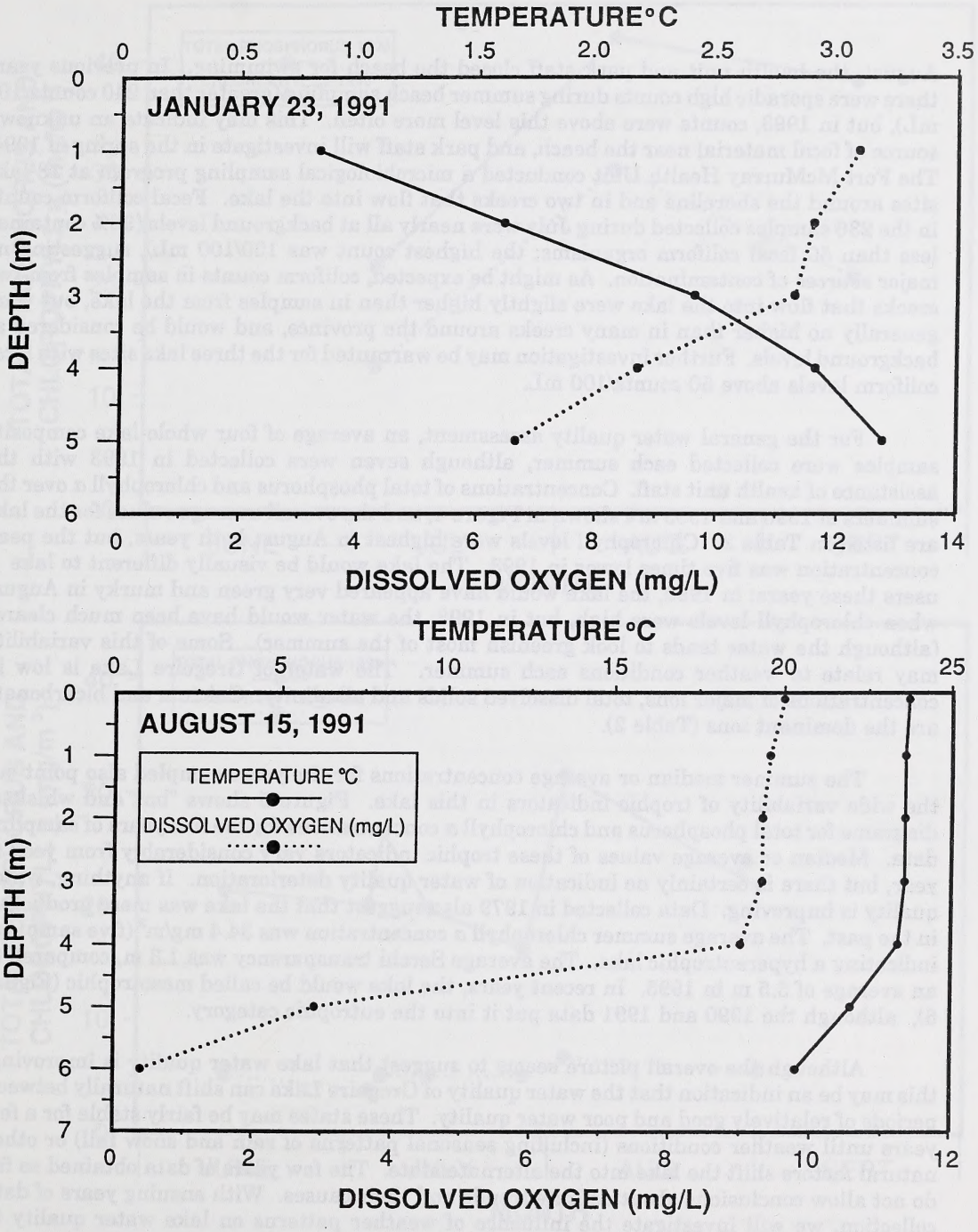


Figure 3. Vertical profiles of temperature and dissolved oxygen in Gregoire Lake.

August, the health unit and park staff closed the beach for swimming. In previous years there were sporadic high counts during summer beach sampling (greater than 240 counts/100 mL), but in 1993, counts were above this level more often. This may indicate an unknown source of fecal material near the beach, and park staff will investigate in the spring of 1994. The Fort McMurray Health Unit conducted a microbiological sampling program at 18 lake sites around the shoreline and in two creeks that flow into the lake. Fecal coliform counts in the 236 samples collected during July were nearly all at background levels (98% contained less than 50 fecal coliform organisms; the highest count was 120/100 mL), suggesting no major sources of contamination. As might be expected, coliform counts in samples from two creeks that flow into the lake were slightly higher than in samples from the lake, but were generally no higher than in many creeks around the province, and would be considered at background levels. Further investigation may be warranted for the three lake sites with fecal coliform levels above 50 counts/100 mL.

For the general water quality assessment, an average of four whole-lake composite samples were collected each summer, although seven were collected in 1993 with the assistance of health unit staff. Concentrations of total phosphorus and chlorophyll *a* over the summers of 1990 and 1993 are shown in Figure 4, and the overall average values for the lake are listed in Table 2. Chlorophyll levels were highest in August both years, but the peak concentration was five times lower in 1993. The lake would be visually different to lake users these years: in 1990, the lake would have appeared very green and murky in August when chlorophyll levels were high, but in 1993, the water would have been much clearer (although the water tends to look greenish most of the summer). Some of this variability may relate to weather conditions each summer. The water of Gregoire Lake is low in concentrations of major ions, total dissolved solids and alkalinity. Calcium and bicarbonate are the dominant ions (Table 2).

The summer median or average concentrations for the years sampled also point out the wide variability of trophic indicators in this lake. Figure 5 shows "box and whisker" diagrams for total phosphorus and chlorophyll *a* concentrations for the five years of sampling data. Median or average values of these trophic indicators vary considerably from year to year, but there is certainly no indication of water quality deterioration. If anything, water quality is improving. Data collected in 1979 also suggest that the lake was more productive in the past. The average summer chlorophyll *a* concentration was 34.4 mg/m^3 (five samples), indicating a hypereutrophic lake. The average Secchi transparency was 1.3 m, compared to an average of 3.5 m in 1993. In recent years, the lake would be called mesotrophic (Figure 6), although the 1990 and 1991 data put it into the eutrophic category.

Although the overall picture seems to suggest that lake water quality is improving, this may be an indication that the water quality of Gregoire Lake can shift naturally between periods of relatively good and poor water quality. These states may be fairly stable for a few years until weather conditions (including seasonal patterns of rain and snow fall) or other natural factors shift the lake into the alternate state. The few years of data obtained so far do not allow conclusions about definite trends and their causes. With ensuing years of data collection, we will investigate the influence of weather patterns on lake water quality to attempt to determine the cause of these apparent trends. In the meantime, the lake has

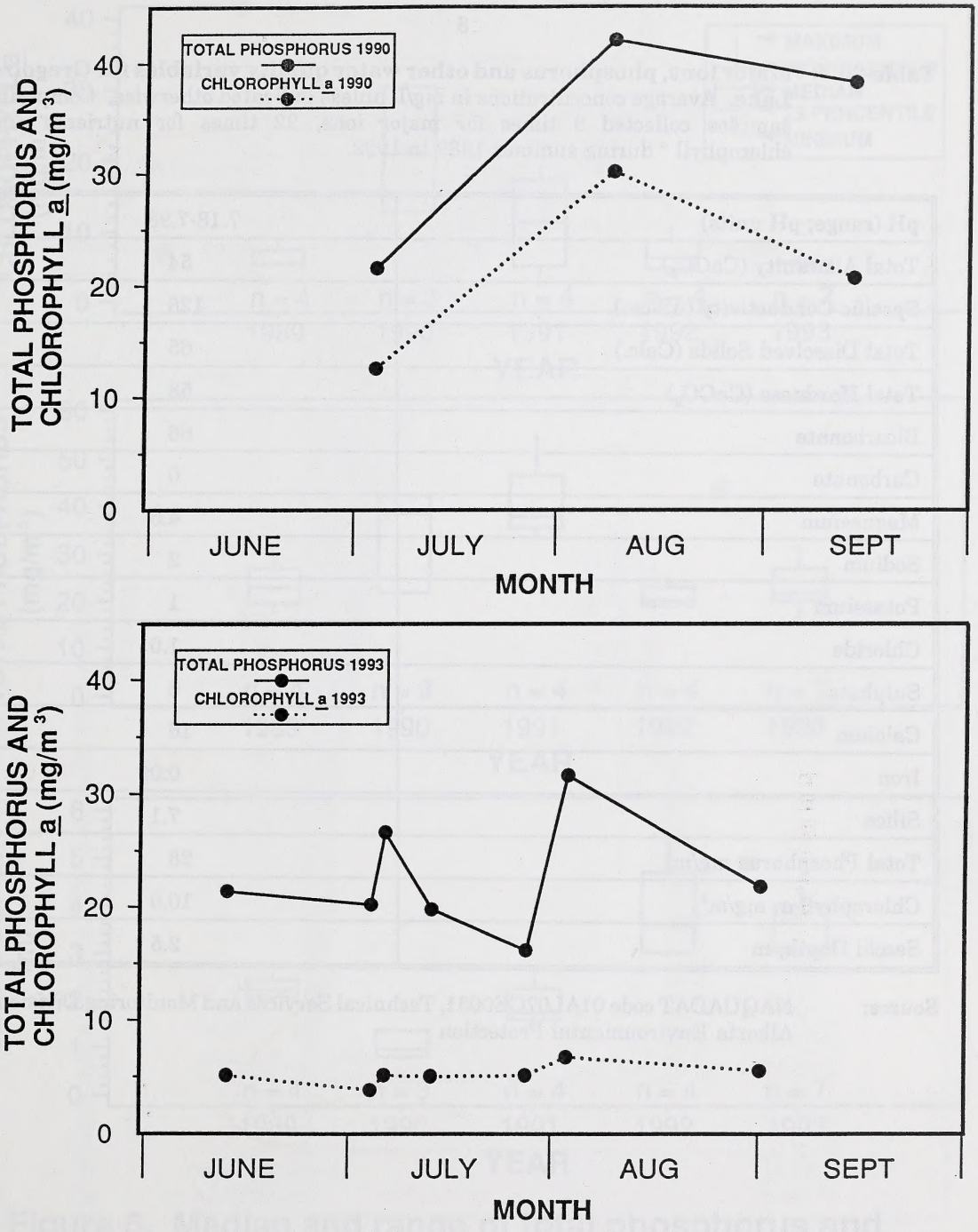


Figure 4. Concentrations of total phosphorus and chlorophyll a in Gregoire Lake, 1990 and 1993.

Table 2. Major ions, phosphorus and other water quality variables for Gregoire Lake. Average concentrations in mg/L unless indicated otherwise. Composite samples collected 9 times for major ions, 22 times for nutrients and chlorophyll [a] during summer 1989 to 1992.

pH (range; pH units)	7.18-7.98
Total Alkalinity ($CaCO_3$)	54
Specific Conductivity (uS/cm)	128
Total Dissolved Solids (Calc.)	65
Total Hardness ($CaCO_3$)	58
Bicarbonate	66
Carbonate	0
Magnesium	4.5
Sodium	2
Potassium	1
Chloride	1.0
Sulphate	8
Calcium	16
Iron	0.09
Silica	7.1
Total Phosphorus mg/m^3	28
Chlorophyll *a*, mg/m^3	10.0
Secchi Depth, m	2.5

Source: NAQUADAT code 01AL07CE0031, Technical Services and Monitoring Division, Alberta Environmental Protection

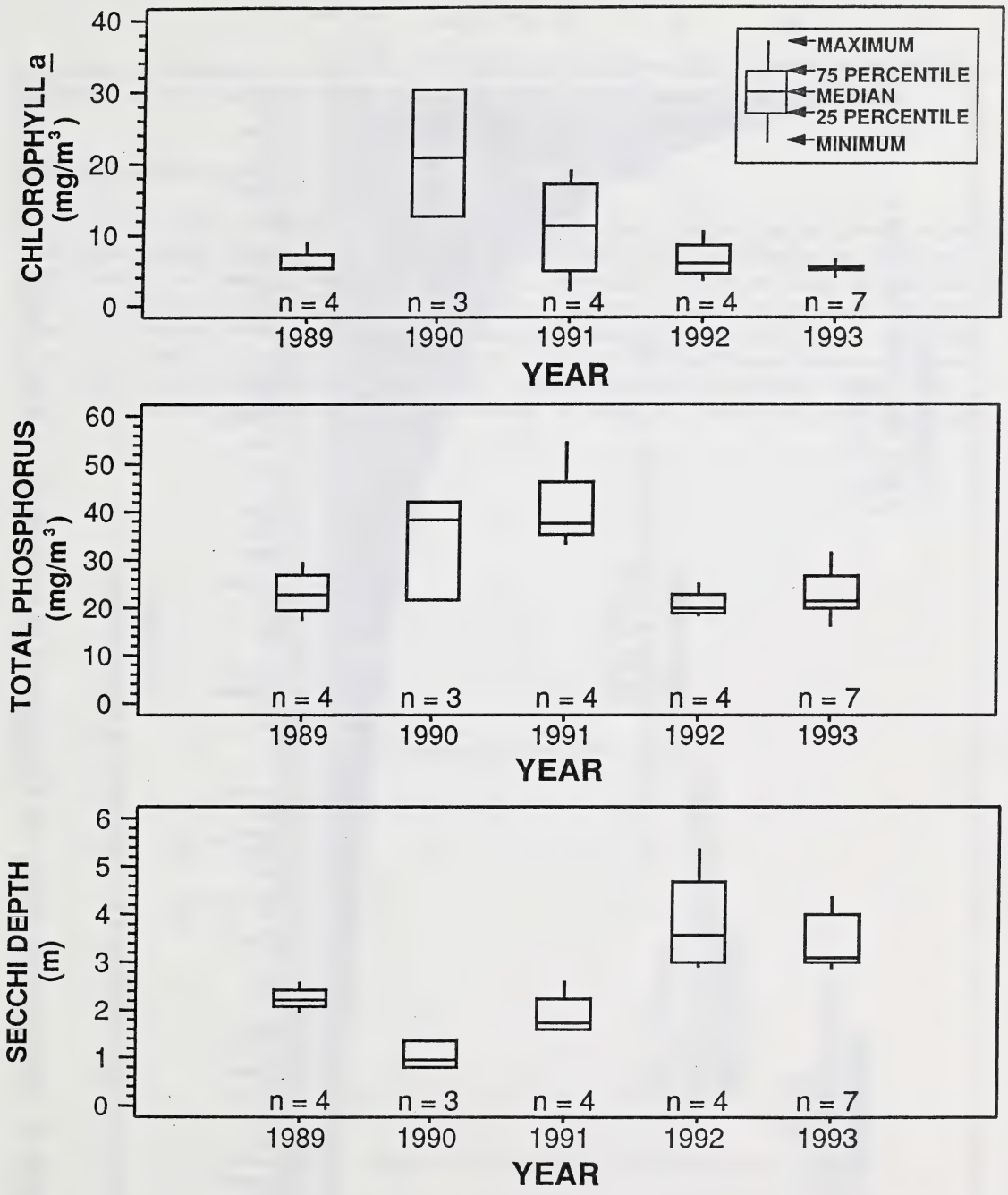
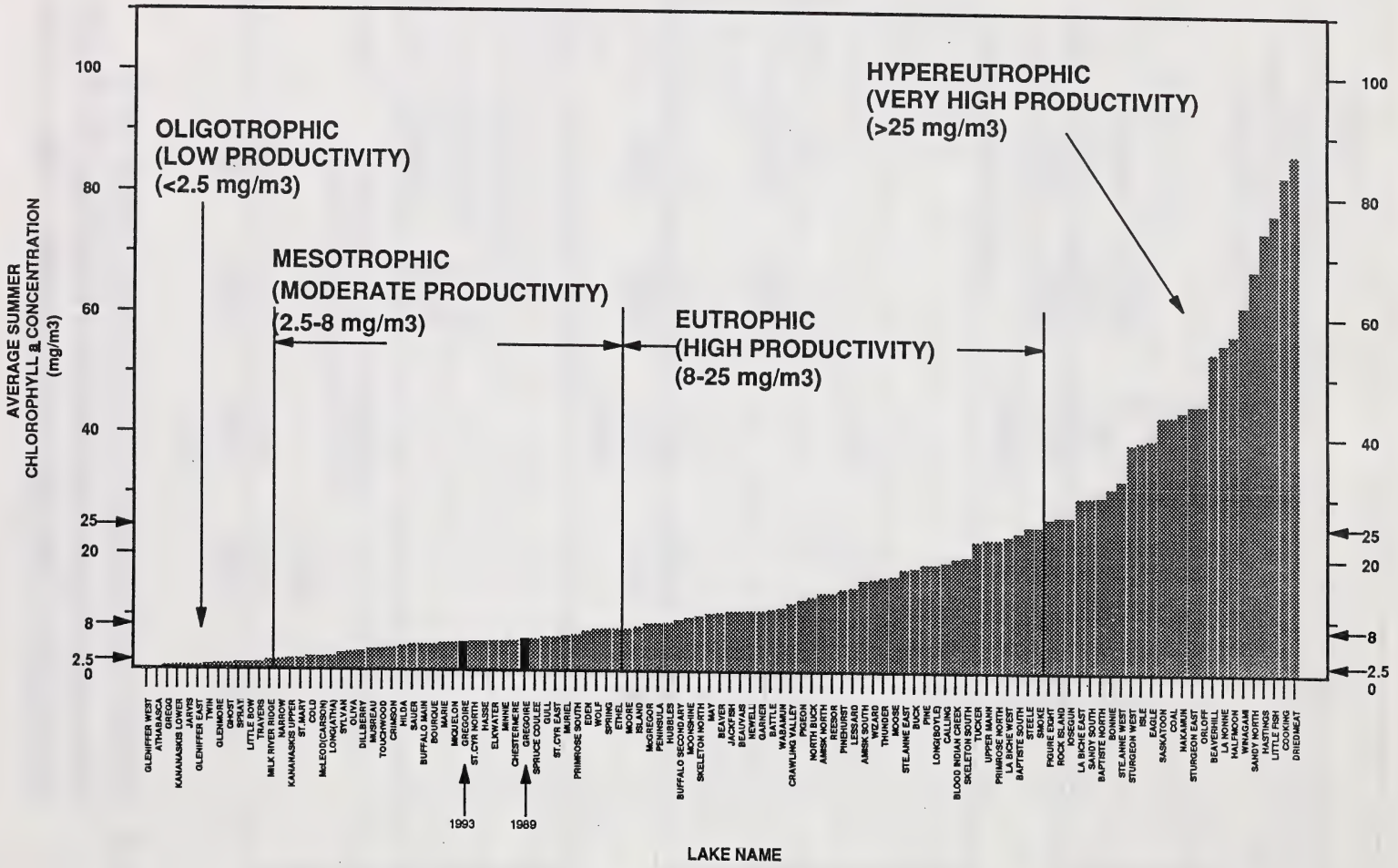


Figure 5. Median and range of total phosphorus and chlorophyll a concentrations and Secchi depth in Gregoire Lake for available data 1989 to 1993.



* Amount of algae estimated by Chlorophyll a concentrations

Figure 6. Amount of algae* in Gregoire Lake compared with other Alberta lakes.

excellent recreational water quality in general, although some effort should be directed toward pinpointing the source of fecal contamination at the provincial park beach.

Acknowledgements

The Technical Services and Monitoring Division sampling program on provincial parks was coordinated by M. Bilyk, phosphorus and chlorophyll samples were analyzed by M. Hussey, and various staff conducted profile sampling. Various staff at Gregoire Lake Provincial Park conducted lake and beach sampling over the past five years. A. Baggstrom and S. Holmes of the Fort McMurray and District Health Unit conducted the microbiological survey in 1993. The report was reviewed by D. Trew of Surface Water Assessment Branch (SWAB), J. Snidal of Planning Division, M. Gervais of the Fort McMurray Health Unit and D. Spackman of Gregoire Lake Provincial Park. B. Halbig of SWAB prepared the graphs.

Appendix. Gregoire Lake water quality 1989-1993. Average summer (May-September) values from euphotic composite samples.

YEAR	CHLOROPHYLL *a* (mg/m^3)	TOTAL PHOSPHORUS (mg/m^3)	SECCHI DEPTH (m)	NUMBER OF SAMPLES
1989	6.2	23	2.3	4
1990	21.2	34	1.0	3
1991	10.9	41	1.9	4
1992	6.5	21	3.9	4
1993	5.2	22	3.5	7
AVERAGE	10.0	28.2	2.5	

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